

Massachusetts Water Resources Authority's Path to Full Resource Recovery

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ABSTRACT

On behalf of the Massachusetts Water Resources Authority (MWRA), CDM Smith Inc. (CDM Smith) recently completed an evaluation of all currently available options for treating and managing the wastewater solids from their Deer Island Treatment Plant (DITP) and determined which would be useful in enhancing existing operations. One impetus for the study is the emergence of new or innovative technologies that may lead to more efficient operation that were not available when the plant was put in operation in 1995. MWRA also desired to explore developments in the industry and residuals management practices of their peer utilities prior to making any major equipment replacement decisions.

In addition to assessment of technologies, the MWRA also needed an evaluation of emerging trends in operating practices, in areas such as co-digestion of alternative feed stocks. This latter concept was very timely since the Massachusetts Department of Environmental Protection intends to ban the landfilling or incineration of some source-separate organics such as food wastes from supermarkets and food-producing industries.

The overarching goal of the study was to optimize MWRA's existing residuals processing operations and identify capital projects that would extend the useful life of these facilities by 20 years. The study recommended improvements which will assist MWRA on a path to full resource recovery. Specific initiatives include co-digestion, modification and expansion of the existing combined heat and power plant, struvite mitigation via nutrient harvesting and other improvements designed to optimize existing thickening, anaerobic digestion, dewatering and thermal drying facilities.

KEYWORDS

Biosolids, Residuals, MWRA, Anaerobic Digestion, Thermal Drying, Co-Digestion, Combined Heat and Power, Struvite Mitigation, Resource Recovery, Sustainability

ABOUT MWRA

The Massachusetts Water Resources Authority (MWRA) provides wholesale water and wastewater services to over 2.5 million customers in 61 communities mostly in eastern Massachusetts, including Boston. MWRA wastewater treatment services are provided at the end of a network of sewer lines that convey wastewater from residences, businesses, and industries to the DITP in Boston Harbor. MWRA collects and treats an average of 1.38 million m³/d (365 MGD) of wastewater per day. Industrial discharges to the sewer system are permitted and controlled through an industrial pretreatment program and industrial discharge permits. The

DITP is one of the largest wastewater treatment plants in the United States, with a peak capacity of 4.92 million m³/d. The effluent is discharged, via a 15 km (9.5 mile) tunnel, into the deeper waters of Massachusetts Bay. Figure 1 shows the Deer Island Treatment Plant Process Flow Diagram.

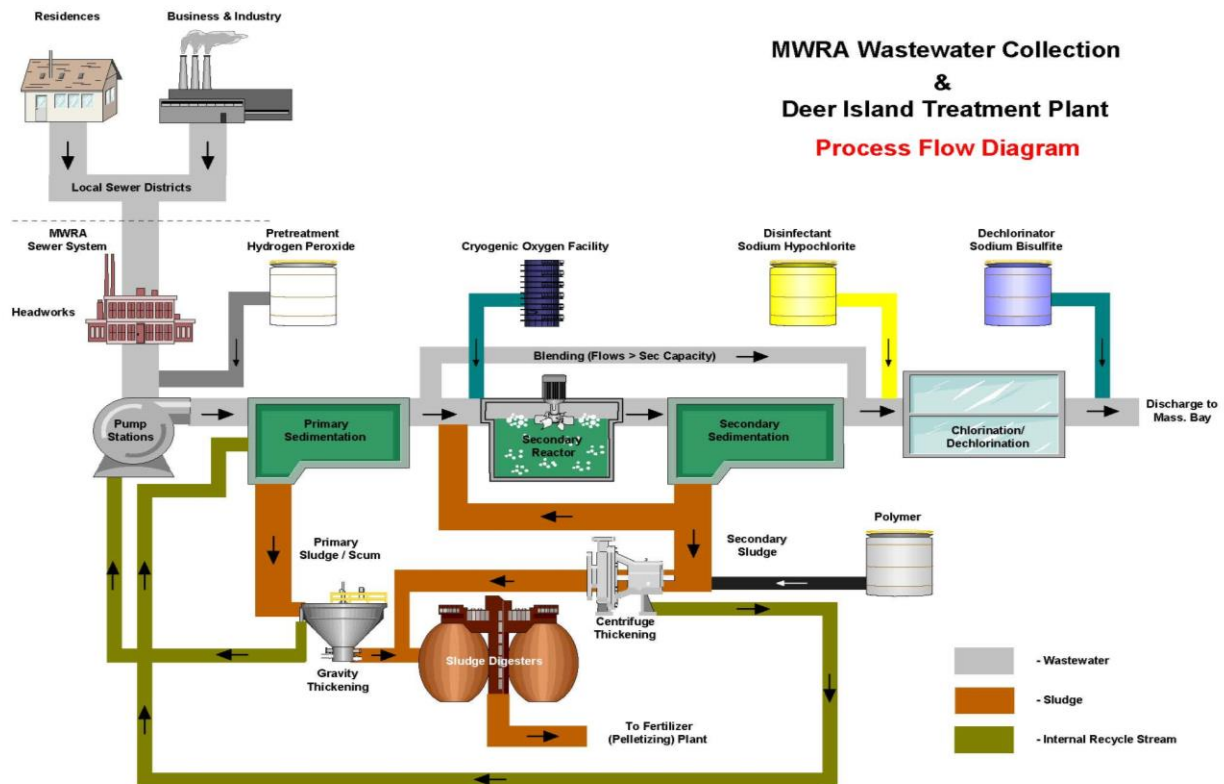


Figure 1 – Deer Island Treatment Plant Process Diagram

MWRA's residuals processing facilities consist of thickening, digestion and biogas utilization facilities at Deer Island, and dewatering and thermal drying facilities at the biosolids processing facility (BPF) in Quincy. Prior to digestion, the sludges are thickened using gravity thickening and centrifuges for the primary and waste activated sludge streams respectively. DITP has twelve, 11400 m³ (3 MG) mesophilic anaerobic digesters. The egg-shaped digesters have a 27 m diameter in the middle and a liquid depth of 39 m. Digested sludge overflows from the digesters to two 11400 m³ sludge/biogas storage tanks. From the storage tanks, the digested sludge is pumped to the BPF through one of two parallel 0.35 m 11 km (7 mile) -long force mains under Boston Harbor. Figure 2 shows MWRA's Residuals Processing Facilities.

Existing Solids Process Flow Diagram

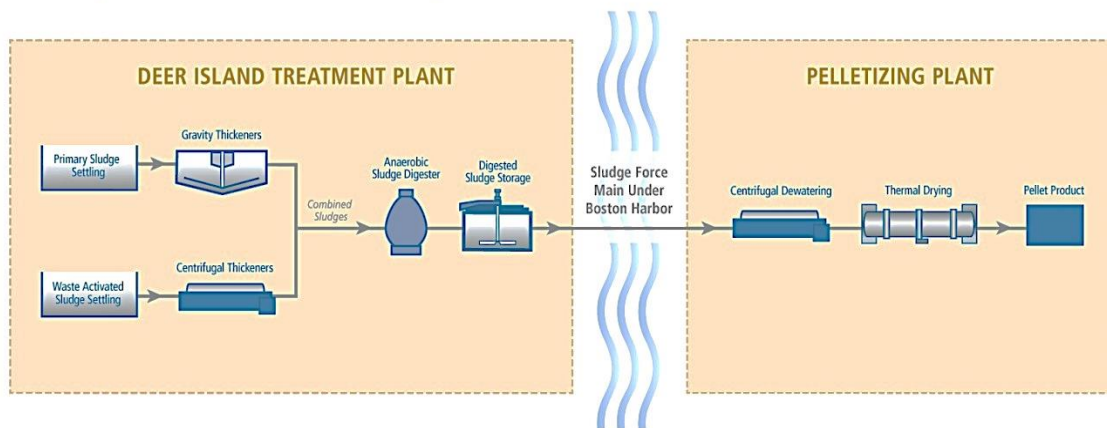


Figure 2 – MWRA’s Residuals Program Facilities

At Quincy the digested sludge is stored in four 3800 m³ storage tanks, then pumped to centrifuges for dewatering. It is then conveyed to the thermal drying portion of the facility mixed with recycled dried sludge before being fed into the rotary drum dryers. The dried product is screened to produce a uniform pellet. A very small percentage of the pellets are bagged and sold locally as a fertilizer product called Bay State Fertilizer as shown in Figure 3. Most of the product is utilized as follows:

- Agricultural uses in this region are mostly for production of corn and hay for dairy animals,
- Turf growers find substantial benefits in using MWRA biosolids pellets to replenish nutrients and organic matter that are harvested with the turf crop,
- Fertilizer blenders utilize MWRA biosolids pellets to balance their fertilizers and provide some slow-release nutrients, and
- Approximately 25% of MWRA biosolids pellets are used as a replacement for coal as a fuel in a cement kiln in Maryland.

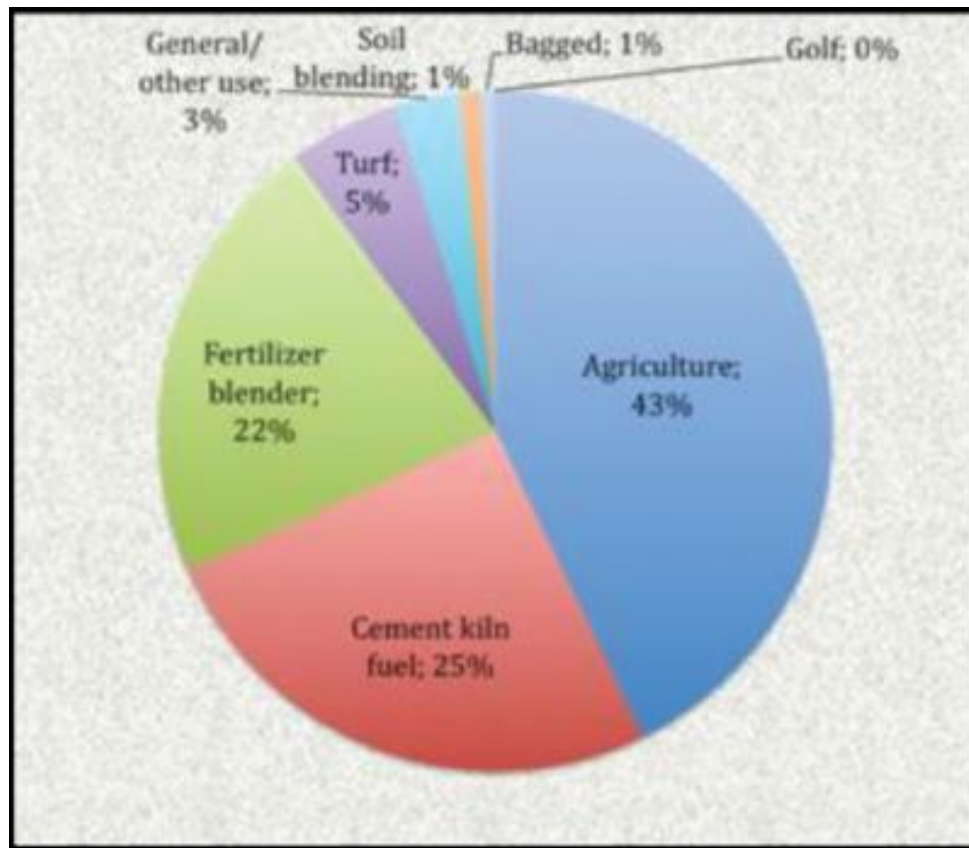


Figure 3 - Distribution of MWRA Biosolids Pellets by Type of Use

With 62 percent volatile solids reduction, the anaerobic digesters at Deer Island produce on average approximately 5200 m³/hr. Peak quantities can be fifty percent above the average based on short-term measurements over several hours. The biogas is currently used as one of two fuels in boilers located at the Deer Island power plant. The boilers produce high temperature, high pressure steam that is fed to steam turbine driven generators. After the steam turbines the steam is converted to high temperature, low pressure water. The hot water is utilized throughout the plant for heating and for digester process needs. Approximately 98 percent of DITP's annual heating demand is met with biogas saving \$15 to 20 million per year. The steam is also used to produce electricity in two steam turbine generators saving an additional \$2 to 3 million annually. On an annual basis, less than 4 percent of the annual quantity of biogas requires flaring.

The DITP power plant has two 60 MW boilers which are capable of accepting either biogas or diesel fuel. The resulting steam is utilized in two steam turbine generators; an 18MW unit, and a newer 1.1 MW unit. The power plant also has two 26 MW combustion-turbine generators for back-up power supply fueled by diesel fuel only.

Figure 4 shows the DITP Digestion Complex and Figure 5 shows the Biosolids Processing Facility in Quincy.



Figure 4 – DITP Digester Complex



Figure 5 - Biosolids Processing Facility in Quincy

SUMMARY OF CURRENT CHALLENGES

The assessment of options for residuals management found that current MWRA processes and operations would likely not benefit from any major change in solids processing. Anaerobic digestion, which MWRA currently employs, has become widely recognized as a wastewater solids management option of choice, because it provides a reduction and stabilization of solids mass and generates a renewable fuel - biogas. In addition, the production of a high-quality (“Class A Exceptional Quality”), uniform, consistent pellet product at the BPF in Quincy is on par with any biosolids management program in the United States. Demand and sales of the final product continue to increase.

Key measures of operational efficiency for MWRA’s residuals management program (e.g. volatile solids reduction, biogas production, net energy consumption, etc.) are amongst the best in the country. Anaerobic digestion is efficient, and that and the operation of the pelletizing plant has been reliable. The rotary drum drying process still represents the technology of choice for many large utilities. In short, mesophilic anaerobic digestion and rotary drum drying should remain core elements of MWRA’s residuals management program. There is no better overall strategy available. These findings align well with MWRA staff goals:

- Improve process efficiency,
- Optimize the existing facility,
- Increase the production of biogas and green energy production, and
- Reduce sludge volumes.

MWRA’s current challenge is to further optimize its existing program to improve efficiencies without disrupting operations. Several technologies are being pursued for additional study and possible integration into MWRA residuals operations:

- Co-digestion of food wastes to increase biogas production,
- Improved combined heat and power system to increase power production from expected higher biogas volumes, and
- Struvite reduction through harvesting to reduce maintenance costs.

These technologies and strategies are the subject of this paper since they all advance resource recovery. However, MWRA also is pursuing other initiatives which will improve plant efficiency. These include screening of primary sludge to reduce maintenance costs and possibly improve sludge digestability, upgrading of centrifuge thickeners used at the DITP and centrifuges used at the BPF for dewatering, and the evaluation of methods to modernize thermal drying facilities. Another initiative that may increase resource recovery is the pretreatment (lysis) of sludge prior to anaerobic digestion. Since MWRA has not decided to implement pretreatment of sludges at this time, these options will not be discussed in this paper.

METHODOLOGY

The goal of this study was to evaluate all currently available options for treating and managing wastewater solids and determine which, if any, might be useful in enhancing MWRA operations.

The objectives of the study included identifying technologies and processes that could help MWRA to:

- Optimize existing facilities and investment,
- Take advantage of emerging technologies,
- Consider lessons learned from other major utilities,
- Maximize solids destruction and gas and energy production,
- Reduce net operating costs,
- Maintain Class A sludge classification and beneficial re-use,
- Consider regulatory trends at federal and state levels,
- Continue to be “good neighbor” in host communities, and
- Operate in a safe and reliable manner.

To accomplish the objectives, a team of CDM Smith engineers and outside consultants with expertise in a wide variety of aspects of residuals management worked in close collaboration with MWRA staff to establish a robust process for evaluating options and making decisions. The team included the following individuals:

- Jan A. Oleszkiewicz, PhD; PEng, BCEE, Distinguished Professor, University of Manitoba,
- Roger Tim Haug, PhD, PE, BCEE, Retired Deputy City Engineer, City of Los Angeles,
- James E. Smith, Jr., D.SC, BCEEM, Retired Senior Environmental Engineer, U.S. Environmental Protection Agency,
- John T. Novak, PhD, BCEE, Professor of Civil Engineering, Virginia-Polytechnic Institute and State University,
- Ned Beecher, Executive Director, North East Biosolids and Residuals Association, and
- Natalie Sierra, PE, Project Manager, RMC Water and Environment.

The agreed-upon multi-step process involved:

1. Identification of all known, current, and practical residuals technology options,
2. Gathering of information on each technology option and development of “snapshots” and case studies of peer utilities, in order to understand current trends in residuals management,
3. Evaluation of current regulatory trends at the national, state, and local level, so as to understand the current and likely future restrictions and guidelines for acceptable residuals management approaches,

4. Selection of technology evaluation criteria and weightings through a cooperative stakeholder process and workshop,
5. An initial screening of technologies and elimination of many that clearly did not meet the identified criteria,
6. A more detailed secondary evaluation and ranking of a final, short list of technology options at a second workshop, and
7. Development of recommendations for further detailed evaluations including lab and bench-scale testing, pilot testing, and concept design of short-list options.

CDM Smith compiled a list of over 100 current, viable technologies being used in treating and managing municipal wastewater residuals. With MWRA staff input, the CDM Smith project team developed tables describing the technologies, draft criteria, and weightings specific to each of these functional subsystems. At a multi-day workshop at the DITP, the criteria and weightings were finalized through a variety of voting procedures and discussion amongst experts with a wide range of knowledge and perspectives. From this, the project team developed scoring guides that were used to screen every identified technology against the established criteria. The result was elimination of all but a “short list” of about 20 technologies that have potential for enhancing MWRA operations.

The next step was to research additional details regarding each of the remaining residuals management technology options. In particular, the study examined emerging technologies that would possibly provide more efficient and cost-effective operations and opportunities for energy recovery or generation. This information was compiled and presented to MWRA in the form of technical memoranda, each of which addressed the technology options, evaluated their operational and economic viability, and recommended whether further consideration of each technology was warranted.

With this information in hand, the entire project team met again with MWRA staff to evaluate the remaining options and recommend those technologies that would be further investigated in future laboratory, bench-scale, and pilot tests.

CO-DIGESTION FEASIBILITY STUDY

The focus of the co-digestion study was codigestion of pre-consumer, source-separated organics (SSO) that would be incorporated into the existing anaerobic digesters at DITP to determine if codigestion at a large metropolitan treatment facility is feasible, and whether the economic benefits outweigh the costs.

Beginning in 1990, the Massachusetts Department of Environmental Protection (MassDEP) banned the disposal of various materials in landfills and waste incinerators. Recently, the agency announced plans to ban source-separated organics (SSO), with the goal of diverting an additional 1000 wet tons per day of SSO by 2020 (basis: 13% TS). These wastes typically include food waste from supermarkets, institutions, food producers and other large generators. MassDEP

expects the ban on disposal of SSO to be in effect by October 1, 2014. Initially the ban will only impact generators of more than one wet ton per week of organic wastes.

When food waste is digested separately, a shortage of micro-nutrients has been observed. However, the performance of anaerobic digestion is improved when primary and secondary sludge is codigested with food wastes. Wastewater sludge provides sufficient micro-nutrients as well as significant alkalinity to buffer varying organic loads. Feeding a digester both food wastes and wastewater sludge results in stable digester performance and increased volatile solids conversion. Food wastes can have a higher Carbon: Nitrogen (C: N) ratio than wastewater sludge, and this can improve the carbon content of the mixed wastes. The increase in biogas production can be significant from codigestion of food waste. The increase in biogas production is greater than the increase in heat demand of the food waste. With this increased biogas production there is an opportunity to focus on power generation first and heat second. The additional biogas can be fed to an internal combustion (IC) engine or gas-turbine generator instead of the existing steam plant. This kind of combined heat and power (CHP) system can have an electrical efficiency of 38 percent. Additionally, heat can be recovered from the IC engines or gas turbines with a thermal efficiency of over 40 percent. A total energy recovery efficiency of 80 percent can be achieved with a combination of electricity and heat.

A range of potential quantities of food waste were examined to fully understand the economic benefits and costs of codigestion. The range was 135,000 to 455,000 kg/d (150 to 500 tons per day). It was assumed that these wastes would be collected and pre-processed at an off-site location by the private sector and transported to the DITP. The economic analysis did not include these pre-processing and transport costs. Table 1 below shows the amount of additional biogas that would be produced from the incremental increase from co-digestion of food waste. The table also shows the equivalent electricity produced by utilizing the additional biogas. For the lower end of the range of food waste quantities, the existing power plant has sufficient additional capacity. For the upper end of the range examined, it was assumed that a new CHP would be constructed. To determine the economic value of biogas, electrical conversion efficiencies of 9 and 38 percent were used for the existing power plant and new CHP facilities respectively. The value of electricity for DITP of \$0.09 per kWh is current average rate. The downstream, post-digestion, biosolids processing costs is \$126/dry tonne (280 \$/dt) for the dewatering and thermal drying at Quincy.

Table 1 - Estimation of Biogas Value

<i>Parameter</i>	<i>Units</i>	<i>150 wtpd case</i>	<i>500 wtpd case</i>
Food Waste Quantities	wet kg/d	135,000	455,000
Biogas Produced	m ³ /d	10,000	34,000
Biogas Energy Produced	MW _{fuel}	2.6	8.8
Biogas Power Conversion	elec/fuel	0.09	0.38
Biogas Power	kW elec	236	3333
Electricity Price	\$/kWh elec	0.09	0.09
Electrical Value	\$/yr (millions)	0.19	2.63

The analysis determined that the monetary benefits from additional biogas production at the DITP are exceeded by the costs for MWRA to process the food waste. Table 2 presents a brief summary of annual costs for the range of food waste considered in the report and an estimate of a “tipping fee” that would be required to treat these wastes in order to breakeven. The first line shows the monetary value of the additional biogas produced by adding food waste to the DITP digesters. The annual processing costs shown on the second line include all processing costs plus the amortized value of capital costs associated with these operations. The third line shows the amount that MWRA would have to charge private firms that deliver food waste to the DITP to “break even.” The last line in the table shows the tipping fee expressed on a unit cost basis: approximately \$0.01 per kg (\$9 per wet ton) or \$0.01 per liter (\$0.04 per gallon) of food waste received. These unit costs are in line with fees charged at other facilities.

Table 2 - Estimate of Food Waste Tipping Fee

<i>Parameter</i>	<i>Quantity of Food Waste</i>	
	<i>150 wtpd</i>	<i>500 wtpd</i>
Annual Biogas Value (Millions)	\$0.2	\$2.6
Annual Processing Costs (Millions)	\$0.7	\$4.2
Break-Even Tipping Fee Revenues (Millions)	\$0.5	\$1.6
Tipping Fee (Rounded)		
Per Wet kg at 13% solids	\$0.01	\$0.01
Per liter	\$0.01	\$0.01

Based in part on the findings of the CDM Smith co-digestion study and research conducted by the University of Massachusetts, MWRA is proceeding with a co-digestion pilot program at the DITP. Starting in mid-2014, pre-processed, source separated organics will be transported to DITP, mixed with thickened sludge and fed to existing digesters. Initially, approximately 50 wtpd at 13% solids of the organics will be fed to a single digester along with wastewater sludge. Over time, the quantities will increase to approximately 150 wtpd and two digesters will be utilized. MWRA plans to carefully monitor pilot and control digesters for both normal process parameters and biogas composition and volume. Based on the results of the pilot program, which could have a duration of one to three years, MWRA may increase the volume of source separated organic received at DITP.

COMBINED HEAT AND POWER STUDY

The DITP is a very large consumer of electric power averaging approximately 18 MW as shown in Figure 6. As shown in Figure 7, approximately 75 percent of the plant power is purchased from the local utility. Most of the remainder is generated by the steam turbine generators (STG) using the steam from the boilers which are fueled with biogas from the anaerobic digesters. The balance of the remaining on-site electrical generation is from the back-up combustion turbines (CTG), which are seldom used, hydro, solar and wind power. One of the major drivers for the combined heat and power (CHP) study was to maximize the overall efficiency of delivering additional electrical power and heat from projected new biogas generation from co-digestion.

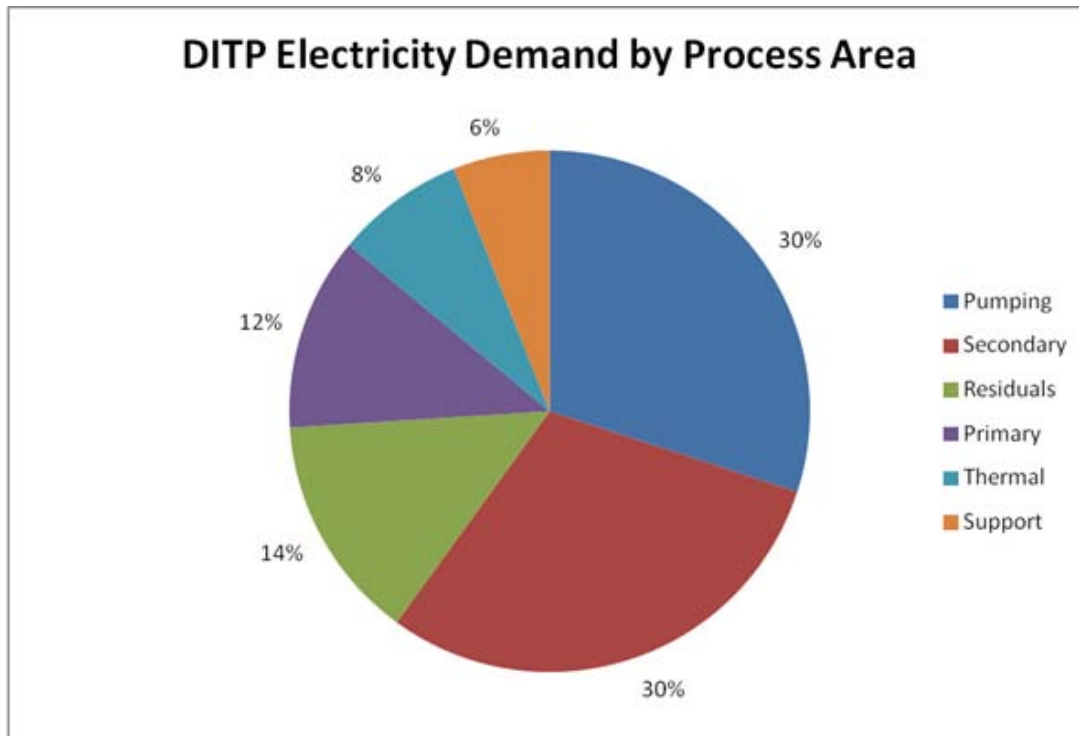


Figure 6 – DITP Electricity Demand by Process Area

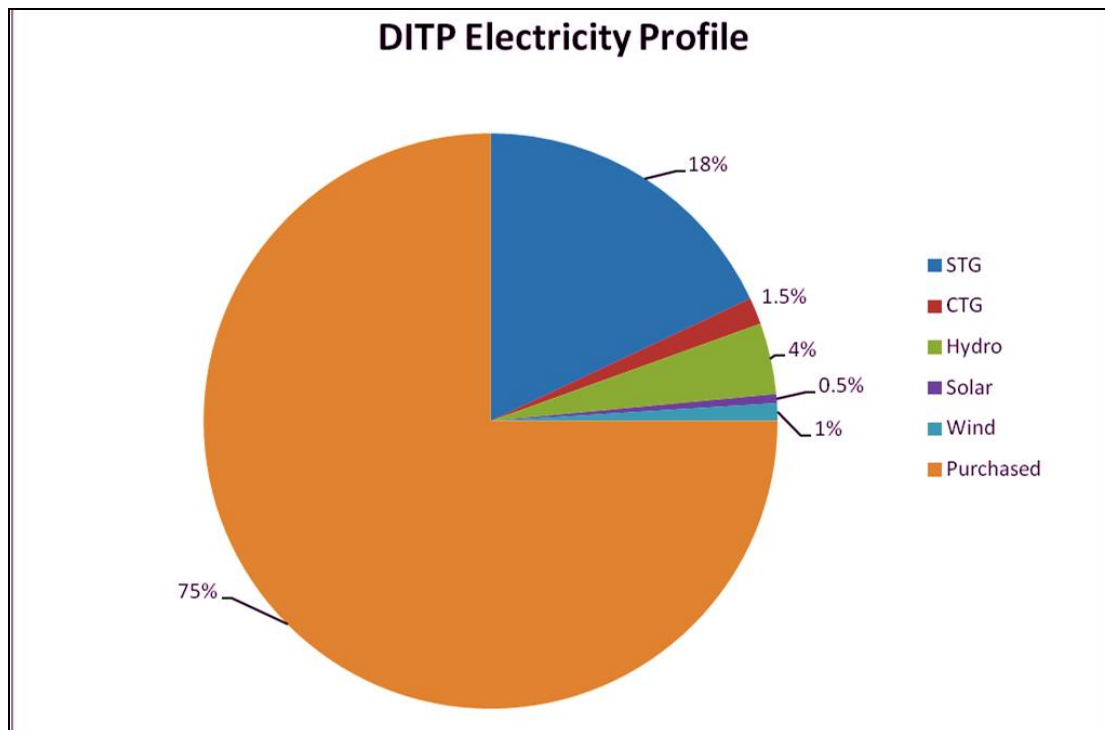


Figure 7 – DITP Electrical Generation by Source

The existing power plant currently uses biogas and fuel oil to generate steam, hot water, and electrical power for use at the DITP. This section describes the relevant characteristics of the existing biogas system, electric power generation and distribution system, and hot water heating system at the plant and how these systems will be impacted by implementing co-digestion. Biogas is produced in the anaerobic digesters, stored in sludge/gas storage tanks, and conveyed to the power plant through compression, cooling, and a transmission pipeline. Additional biogas management equipment is needed to relieve the current biogas bottlenecks and support a new co-digestion system. The key components of the existing and new biogas management equipment include:

- Dystor Units - Biogas produced by anaerobic digestion is captured and stored in two Dystor units that serve as covers for the sludge/gas storage tanks. This gas storage mitigates the variation in gas production rates and helps stabilize the gas system supply pressure. The quantity of existing gas storage appears sufficient for a future scenario to adequately dampen variations in biogas production and provide system flexibility.
- Gas Compressors at Gas Handling Building- Three single-stage, reciprocating type compressors currently increase the pressure from approximately 0.03 bar to approximately 0.7 bar and route biogas from the Dystor units to the power plant. A fourth compressor of similar size-or replacement of this system with three larger compressors-will be needed to properly convey the biogas produced by co-digestion to the power plant and provide adequate capacity and redundancy.
- Gas Transmission Pipeline - There is a single 0.4 m diameter HDPE pipeline conveying biogas from the Gas Handling Building to the Power Plant. The estimated capacity of this pipeline is approximately 10,000 m³/hr. This pipeline may be adequate to convey the co-digestion gas generation rates; however, a parallel pipeline is recommended because the single pipeline represents a single point of failure due to the lack of redundancy.
- Gas Treatment - The existing Lo-Cat system treats the biogas to reduce water content, and sulfur to protect the existing equipment and reduce air emissions. The system is 16 years old. An additional treatment train-or replacement with a larger system-will be needed to process future gas production rates and meet equipment redundancy objectives. The new system would remove hydrogen sulfide, water, and siloxane.
- Gas Compressors - A train of three gas compressors boost the pressure of the biogas after the Lo-Cat system to 1.4 bar. The biogas is then routed through coalescing filters and to the existing boilers. While compressor capacity is adequate for the increased gas production rates, it is expected that the output pressure may be too low for new CHP equipment (particularly if gas turbine driven generators are selected). For this reason, a new higher pressure compressor is required.

The DITP electric system consists of the utility feed to the Main Switchgear Building and a medium voltage loop that follows the perimeter of the plant and distributes the power throughout the plant. The utility power is backed up by the two combustion turbine generators fueled by fuel oil from the adjacent fuel oil storage tanks. The existing power plant operates with an average

electrical efficiency of approximately 8.6% and has a gross electrical production of 2.9 MW_e. Plant data indicates that consumption of power for running loads within the power plant consumes approximately 51% of the power produced. The remaining power generated is available for use by the DITP facilities.

The project team evaluated the electrical tie-in options for new CHP facilities and concluded that future CHP facilities should generally be located near the Enterprise Room of the existing power plant. One key component of the plant electrical system is the switchgear. The switchgear used to transfer power produced on-site into the local DITP grid is located in the Main Switchgear Building, adjacent to the power plant. To reduce the cost of site electrical system upgrades, any future power generation equipment should be located near the Main Switchgear Building. Siting all electric power production equipment at the power plant location allows ease of electrical system tie-in and consolidation of skill-specific maintenance activities. This area is also less congested than the DITP site near the digesters. Either technology considered in this study (gas turbines or IC engines) could be installed at this location.

Heat for the DITP process and space demands is supplied from the power plant. The existing system provides heat in the form of steam and transfers this heat to a hot water circulation loop that delivers hot water to the anaerobic digesters and to building space heaters located throughout DITP. The circulation loop consists of a 20-inch diameter hot water supply and hot water return piping.

The plant heat production by the power plant has been relatively consistent, varying between 18 MW_{th} and 22 MW_{th} (MW_{th} is thermal energy rate) throughout the year on average. Although the average plant heat production under current loading is 20.1 MW_{th}, the average annual heat demand is estimated to be only 14.2 MW_{th}. Thus for many months of the year, the DITP currently wastes excess heat to the plant effluent stream. The recommended CHP project will allow DITP to produce more usable energy (in the form of electricity) while still meeting or exceeding DITP's current heat production rate throughout the year.

A co-digestion system receiving 500 wtpd is expected to increase biogas production by 29%. In contrast, the increased heat and power required to operate under co-digestion conditions with 1-2 additional digesters in service is nominal. The additional energy produced by co-digestion in the form of biogas is significantly higher than both the additional heat and electricity required to operate the co-digestion system. This creates an opportunity for DITP to leverage the available on-site energy supply to reduce the cost of purchased electricity.

To introduce CHP technology options for DITP, it is first useful to understand the difference between bottoming cycle and topping cycle systems. A bottoming cycle CHP system like the one used at DITP produces heat first (such as steam) and then uses excess heat produced by the process to generate power (typically from a steam turbine). Bottoming cycle technology is normally utilized at larger capacity power plants (greater than 50 MW) where relatively high electrical efficiencies can be achieved (30 to 40%). In contrast, a topping cycle CHP system produces power first (using an engine or turbine) and then recovers waste heat (e.g., engine jacket water, engine or gas turbine exhaust) second. As a point of comparison, new topping cycle CHP systems can be expected to achieve 30 to 40% electrical efficiency and approximately 40%

heat recovery efficiency, for a combined total of 70 to 80% total efficiency. In this study, two types of topping cycle technologies were considered for the DITP: gas turbines (GTs) and internal combustion (IC) engines. The higher electrical efficiency of these technologies presents an opportunity to MWRA to realize a higher value from the biogas.

A biogas fueled gas turbine (GT) driven generator with a duct burner produces electricity and additional biogas can be fed to the duct burner for increased heat production. The duct burner is an after burner that combusts a discrete fuel stream (e.g., biogas in this case) along with the turbine exhaust products to heat steam or hot water. The duct burner allows for over 90% efficient heat delivery from the burner.

An internal combustion (IC) engine is used to drive an electric generator and heat is recovered from the engine jacket water, lube oil, and exhaust in the form of hot water. Lean burn combustion (meaning the stoichiometric ratio of air to fuel is > 1.0) is the common method used in IC engines to reduce NO_x emissions. IC engines are available in both naturally aspirated and turbo-charged models, with draw-through configuration available on several models. The draw-through configuration allows the biogas to be fed to the engine at lower pressures because it is mixed with air in the carburetor and drawn through the turbocharger. Engine controls adjust the air-fuel ratio and combustion timing to maintain efficiency and emissions given varying fuel heat values.

The two CHP technologies were screened using several criteria to determine the best fit for the DITP and MWRA. Long-term, it is desirable to have the initial CHP system expandable to meet the entire plant heat and power demand. A GT system could meet the plant-wide heat demand with one duty unit, but numerous IC engines would be required. The initial project phase would involve installing either one 4.6MW_e GT or two 1.8MW_e IC engines.

Key findings of the CHP study are as follows:

- Either GT or IC engine technology are feasible CHP options for DITP and are expected to have similar capital costs per power unit produced.
- For a given output power, GTs will have lower operating and maintenance costs.
- Emissions of priority pollutants (NO_x, SO₂, CO, PM₁₀, and UHC) will be lower per unit power produced, suggesting that GTs will be easier to permit and project implementation time will be shorter.
- Existing operation and maintenance staff are already familiar and skilled with gas turbine technology.
- The redundancy offered for heat production with the duct burner option included in the GT package favors this technology over IC engines for the DITP.

- Phasing and long-term facility siting favor the GTs because they could be added in increments, with 2-3 units able to eventually replace the power plant (i.e., when that equipment reaches its useful life).

The screening evaluation indicates that GT technology appears to be the better fit for DITP. Better compatibility with existing operations, lower operating cost, greater flexibility for production of heat and power, improved redundancy, and easier project implementation is anticipated for new GT facilities over IC engine technology. A schematic of the proposed combined heat and power plant and their relationship to the existing power plant is shown in Figure 8.

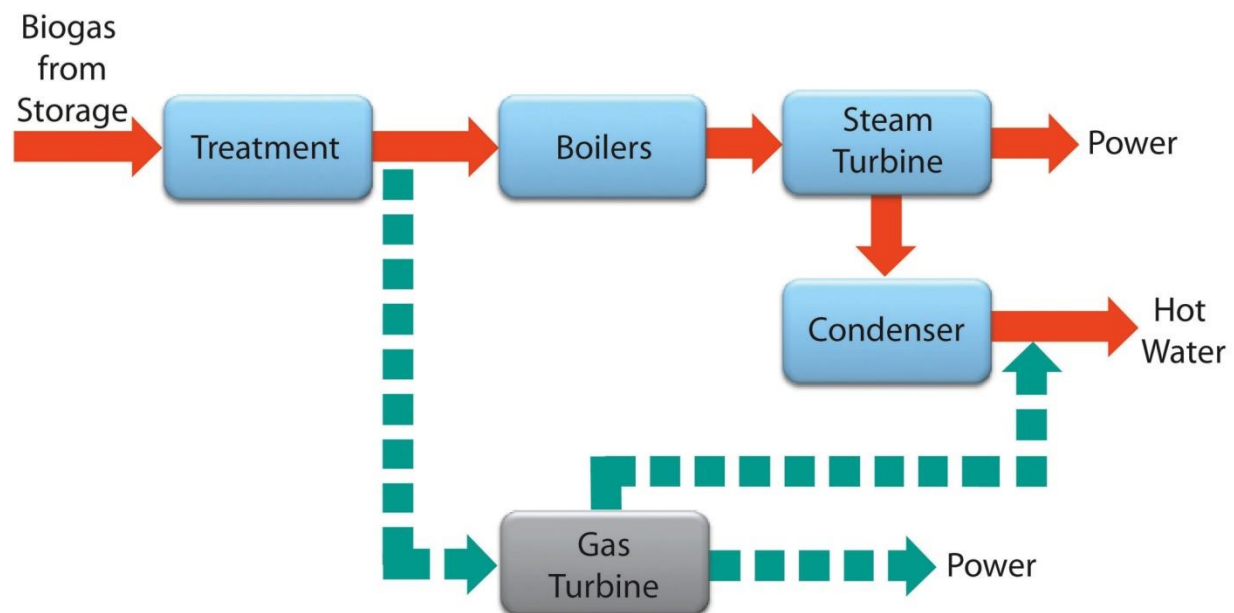


Figure 8 – Proposed Combined Heat and Power Plant

STRUVITE MITIGATION

Precipitation of rock-hard minerals – struvite and vivianite – on pipes and other equipment at DITP and the pelletizing plant interfere with processes and require regular maintenance as shown in Figure 9.

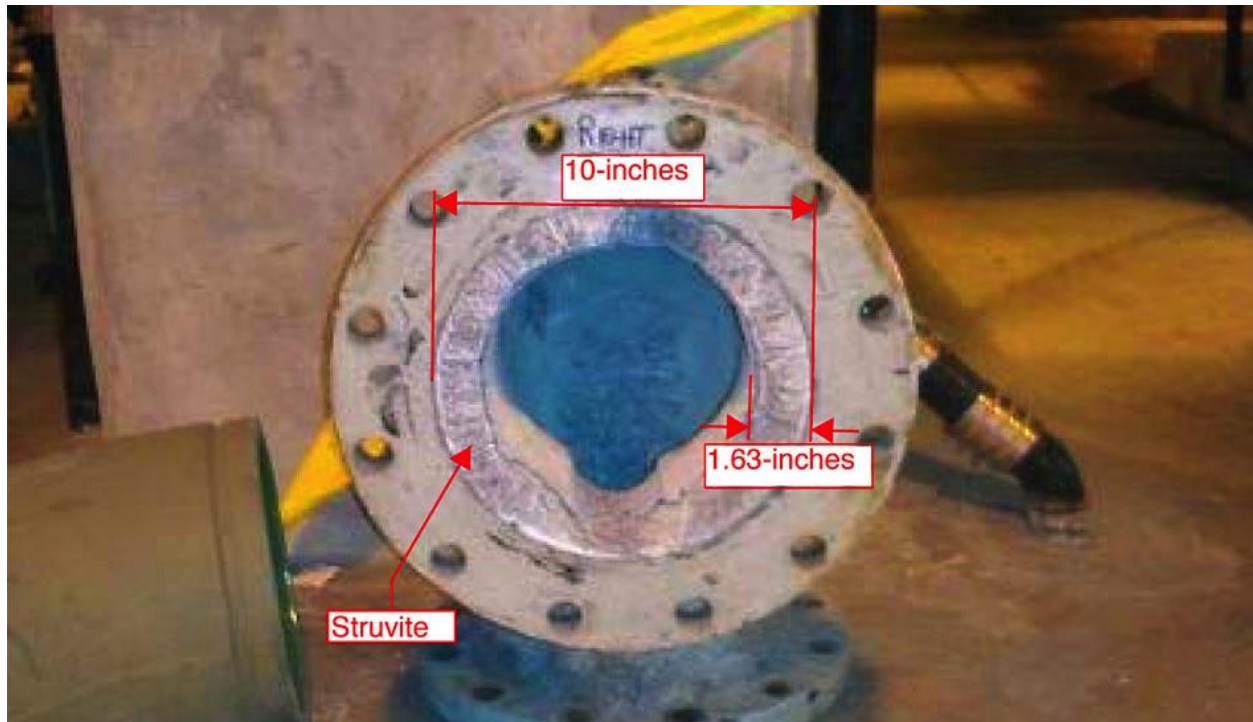


Figure 9 - Operations and Maintenance Problems Caused By Struvite Buildup

Several struvite and vivianite management alternatives that may be appropriate were evaluated. The general categories of these alternatives include:

- Ways to minimize build-up of these precipitates via operational and maintenance practices,
- Chemical addition,
- Harvesting struvite from one or more sidestreams, and
- Process changes which could shift a portion of the contributing ions from the solids stream into the liquid stream.

The project team provided MWRA with details about several possible process configurations and technology options that might address this issue. One of the options selected for further consideration is to harvest struvite from the digested sludge at Deer Island Treatment Plant. CDM Smith worked with Ostara Corporation and based the preliminary engineering on Ostara's Pearl Process. In this scenario sludge would continue to be processed as it currently does: thickened primary sludge is combined with thickened waste activated sludge and sent to the anaerobic digesters. Digested sludge will continue to flow to the sludge storage tanks before being pumped to the Quincy Pelletizing Plant for further processing. However, in order to harvest the struvite, a portion of the digested sludge will be withdrawn before storage. This sludge will be sent to an isolated set of thickening centrifuges where the solids will be separated from the centrate and the centrate can be sent to the harvesting process. The thickened digested sludge will be pumped back to the digesters or sent to the BPF. The centrate after treatment will

have 80 to 90% of the phosphorus removed and 20 to 30% of the nitrogen removed. The treated centrate recombined with the sludge would dilute the struvite forming ions in the digesters and in the digested sludge force mains to the Quincy Pelletizing Plant. The anaerobic digesters would continue to be operated as they are and serve as fermenters without any need to designate digester(s) as separate isolated fermenters, as in some other options investigated. This alternative also utilizes existing standby thickening centrifuges already on island, minimizing the need for new equipment. Figure 10 below shows the proposed process flow diagram.

The recommended next steps for MWRA involve laboratory and field-testing to better understand the feasibility and effectiveness of the potential alternatives. The results of laboratory and bench-scale testing will determine the most cost-effective way to reduce and/or harvest struvite and will also determine any consequential beneficial or adverse impacts. In addition to laboratory and bench scale testing, pilot scale testing may also become necessary before implementation at the full scale. Struvite reduction technology will help reduce in-plant struvite issues, the level of nitrogen (N) in the treated effluent, and the level of phosphorus (P) in the biosolids product, making the biosolids a more balanced fertilizer.

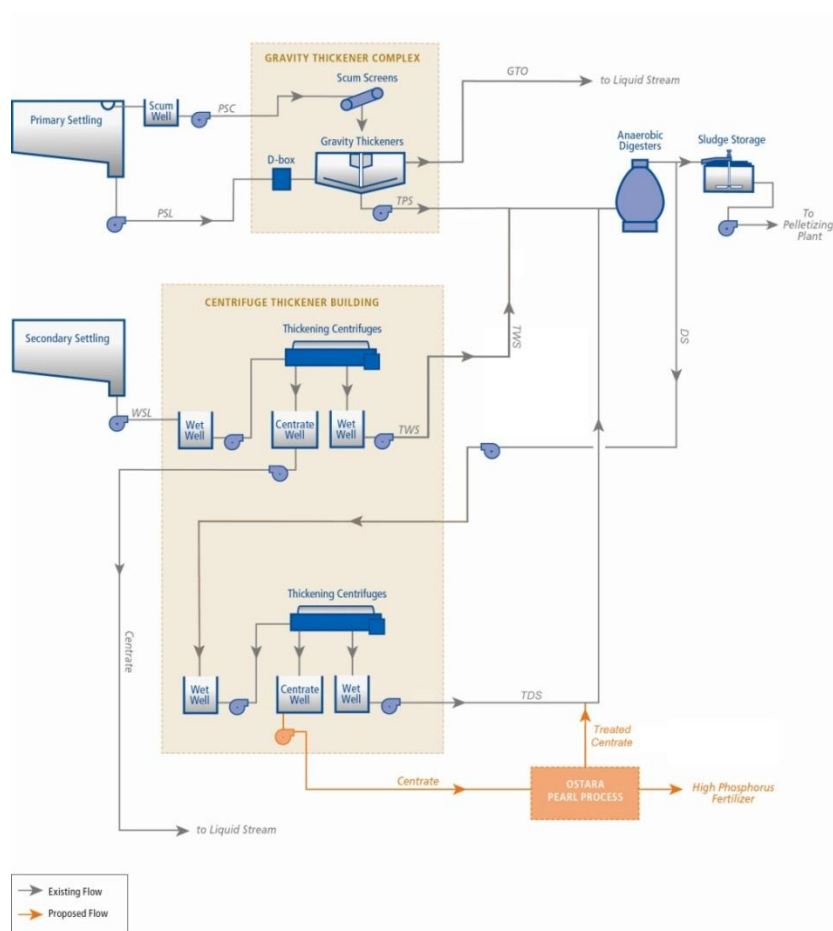


Figure 10 – Solids Processing Flow Diagram – Struvite Harvesting from Digested Sludge at DITP

SUMMARY

This study's review of current MWRA operations found that MWRA facilities meet the regulatory standards for which they were built and have above average performance. The facilities have a commendable achievement with resources recovery. Nearly all the digester biogas is utilized in an on-site power plant satisfying 98 percent of annual process and building needs and having a gross electrical product of nearly 3 MW. Reviews of peer utility experiences, as well as regulatory trends at the local, state, and federal levels, found no significant foreseeable obstacles to continued operation of these facilities.

Mesophilic anaerobic digestion and rotary drum heat-drying of wastewater residuals – which are already operating at MWRA facilities – are currently highly favored technologies, because of their efficiencies, their proven record, and their generation of renewable energy and recyclable biosolids. The project team and MWRA staff had strong consensus that these technologies should continue to be core elements of MWRA's residuals management and resource recovery systems – and not just because of the costs already sunk into them, but also because they are best options for a myriad of environmental and social reasons.

Comparing MWRA's wastewater treatment and residuals management operations to those of other facilities in North America indicates that current MWRA operations are quite effective and efficient, producing and recycling valuable recovered resources: clean water, biosolids, and biogas. Today, around the world, businesses, industries, governments, and non-governmental organizations are striving to attain sustainability in their operations. With 26% of its power needs met through a variety of self-generation sources, MWRA residuals processing operations are already a long way toward being sustainable, and they are poised to be more so. The current technologies in use include anaerobic digestion that generates a renewable fuel – biogas – and thermal drying that produces a high-quality, recyclable pelletized biosolids fertilizer and fuel.

However, the study found that there are other opportunities for improving the residuals management operations and also enhancing resource recovery. These technologies are:

- The co-digestion of up to 455,000 kg per day of food wastes has the potential to generate an additional 34,000 m³ of biogas per day,
- The addition of a 4.6 MW steam-producing gas turbine will substantially increase the percent of electrical production at the DITP from renewable sources, and
- The installation of equipment to harvest struvite from digested sludge will significantly reduce plant maintenance and produce a saleable, high-phosphorus fertilizer product.

MWRA is already a leader in sustainable water resources recovery, closing in on sustainability by recovering water, nutrients, organic matter, and energy from wastewater and biosolids. Its current core residuals management systems – mesophilic anaerobic digestion and thermal drying and pelletizing – have proven successful over many years. However, the study also found that there are specific technology updates that can help the MWRA advance its goals and place it on a path to full resource recovery. It recommends steps for MWRA to take in the next few years to ensure another two decades of successful residuals management for the Boston area communities it serves.

REFERENCES

Residuals Processing Facilities Technology Options Assessment for Massachusetts Water Resources Authority, CDM Smith, January, 2014.